MISCELLANEOUS GEOLOGIC INVESTIGATIONS MAP I-718

EXPLANATION

Dashed where approximately located or indefinite

Fault Queried where doubtful. U, upthrown side; D, downthrown side

At Playa Sardinera probably chiefly crossbedding Apparent dip of beds where accurate strike

information unobtainable Queried where uncertain. Dot indicates point of observation

Strike and dip of beds

Apparent horizontal beds  $\Longrightarrow$  6

Apparent dip of crossbeds

Dot indicates point of observation \_\_\_\_\_10 ---?---?---Structure contour

Drawn on top of the Isla de Mona Dolomite; long dashed where approximately located; short dashed where reference plane projects above

ground surface; queried where doubtful. Contour interval 10 m, datum is mean sea level Low scarp on upland surface

Ticks on downslope side; clustered ticks where intermittently or poorly developed (Kaye, 1959, p. 150-151)

Approximate location of cave

Entrance to cave is known or is believed to be in the cliff or escarpment

face directly in line with the leader. Letters refer to table 2 Depth contour Based on soundings from U.S. Coast and Geodetic Survey Chart 901 and

on an unpublished marine seismic depth recorder line along the 67°50'

meridian (L. E. Garrison, U.S. Geological Survey, written commun.,

1969). Contour interval 10, 20, and 100 fathoms, dependent on density

of bathymetric data; datum is mean sea level

munum Seaward edge of fringing reef

Approximates 2-fathom depth contour

Orientation and linear extent of fore-reef grooves

Only a few grooves are shown. Locally they are very numerous with

spacing as close as 5 m (Kaye, 1959, pl. 12)

GENERAL COMMENTS A report by Kaye (1959) contains appreciable data and inter-

tains no quartz or heavy-mineral grains; locally includes rubble from

raised-reef deposits and beach rock. Beach rock localities shown by thick lines parallel to shore. Thickness ranges from 0 to at least 3 m

sea on the northern periphery; other boulder deposits are chiefly rubble from the Lirio Limestone and include boulders as large as 50 m in long

Raised reef flat

Fragmental grayish-orange-pink limestone chiefly composed of fossils

and fossil fragments; commonly case hardened, locally somewhat chalky. Thickness ranges from 0 to at least 3 m; locally may be as

Aluminous lateritic soil Dark-reddish-brown clay and silt; quartz free; accidental large fragments

include rootlets, wood fragments and snail shells; commonly friable, but locally well cemented by calcite. Thickness ranges from 0 to about 1 m

UNCONFORMITY

Lirio Limestone Very pale orange to grayish-orange-pink fine-grained limestone, thick

and very thick bedded, locally crossbedded; commonly very well indu-

rated, perhaps as a result of surficial solution and reprecipitation; locally chalky; cavernous, most notably in lower 10 m at the periphery

of Isla de Mona. Maximum exposed thickness is about 40 m. Areal

extent of cave system in the Lirio Limestone shown by pattern; dots

show principal entrances to caves. Roman numerals refer to table 1.

POSSIBLE UNCONFORMITY

Very pale orange to moderate-orange-pink finely crystalline calcitic dolo-

mite, thick and very thick bedded, locally crossbedded, well indurated

Zones of limestone about 5 m thick occur locally at the top and about

15 m and 50 m stratigraphically below the upper contact. Base con-

cealed by the sea. Maximum exposed thickness is about 80 m

Letter N in south center of island refers to table 2

pretations on the geology of Isla de Mona as well as a petrographic study of the cave phosphorites by Z. S. Altschuler. We recommend that this report be read in conjunction with the large-scale geologic map presented here. In the course of preparing the map, we traversed more than 60 km on the surface of Isla de Mona, including a circuit of the island on foot and traverses to several points in the interior. In addition, cave surveys by tape and compass were about 5 km in total length, and pace-and-compass and reconnaissance cave traverses probably were twice as long.

Traverses of the upland surface are made difficult by dense thorny brush. Those that we made indicated that the surface is underlain by essentially homogeneous Lirio Limestone except in the Bajura de los Cerezos, where we found calcitic dolomite, here labelled Isla de Mona Dolomite.

Along the peripheral cliffs of Isla de Mona, exposures generally are good, except on the east and west coasts where laterally continuous boulder deposits conceal the contact relations of the two bedrock formations in many places. The cliffs of the southern coast from the vicinity of Playa del Uvero to Playa de Pájaros are chiefly in Lirio Limestone, with dis-continuous exposures of Isla de Mona Dolomite at the base. These exposures are interpreted as axial zones of gentle anti-clines (sections A-A' and B-B'). From northwest of Playa del Uvero northwestward to Playa Sardinera the cliffs are wholly Lirio Limestone, whereas north of the west coast boulder deposits, the Isla de Mona Dolomite crops out beneath the Lirio in the cliffs and the limestone-dolomite contact rises northward to Cabo Barrionuevo where the Lirio is only a thin cap at the top of the cliff. From Cabo Barrionuevo east to Cabo el Toro and south to the vicinity of Punta Este, this thin cap of Lirio Limestone is present almost continuously at the top of the cliffs; from the fault to Cabo el Toro the Lirio is continuous, with a thickness ranging from about 1 to perhaps 10 m. Southwest of Punta Este the Isla de Mona Dolomite again is concealed by boulder deposits, and it does not crop out at Playa de Pájaros.

This generally excellent control around the periphery of the island, coupled with the sparse data from the interior and aerial photographic interpretation have allowed the structural interpretation shown by the structure contours on the map. Isla Monito was not visited by us. Its geology is interpreted from photographs, from binocular study from Isla de Mona, and from low-level air reconnaissance. The cavernous upper unit of Isla Monito probably is the Lirio Limestone and the lower unit probably is the Isla de Mona Dolomite. The contact between these units dips about 3° SW. This interpretation is in agreement with that of Kaye (1959, p. 147).

CLIFFS IN THE ISLA DE MONA DOLOMITE The base map upon which the geology is drawn does not accurately portray the cliffs developed chiefly in the Isla de Mona Dolomite. These cliffs from the vicinity of Punta Este north around the coast to the vicinity of Punta El Capitán on the northwest are almost entirely sheer to the sea. For the purposes of this map, the geology of the cliffs of Isla de Mona has been adapted to the base map. Thus a thin band of Isla de Mona Dolomite is shown along the coast from Punta Este northward and westward to the vicinity of Punta El Capitán. If the base were more accurate in its depiction of the cliffs only sporadic outcrops of Isla de Mona Dolomite would be seen in plan view. Photographs of the cliffs are included in the report by Kaye (1959).

Isla de Mona is noted for its great numbers of caves, and

many believe that one can travel underground for great distances inland. The most frequently suggested lengthy underground connection is between the northern part of Cueva de los Pájaros system (table 1, cave IV) northward to Cuevas del Centro (Luis A. Ramírez and others, oral communs., 1964). In the course of geologic mapping a number of caves were surveyed (table 1) and others reconnoitered and we discovered that at no point could we penetrate farther than 240 m inland from the cliffs of the island. Moreover, we found that passages led off from the bottoms of sinkholes in the upland surface only near the cliffs and along Camino los Cerezos (table 2, cave N and footnote 7); at Cuevas del Centro there is only one deep sinkhole, and no passages lead laterally from this sinkhole. In short, extensive cave development appears to be limited to a zone on the island's periphery. Earlier beliefs probably result from a lack of surveying and from the fact that straight-line movement in the caves is difficult, giving the impression of greater penetration than actually is

Caves in the Isla de Mona Dolomite are few and are relatively small. The chief locus of cave formation was in the lower few meters of the Lirio Limestone adjacent to the cliffs, and the floors of these caves in this zone commonly are at the Lirio Limestone-Isla de Mona Dolomite contact. Cave systems surveyed in this zone are more than 400,000 m<sup>2</sup> in aggregate area (table 1). Caves also occur in zones higher in the Lirio, but the total of their areas most probably is very small compared to the areas of caves in the basal Lirio Limestone.

Table 1. Caves investigated  Map Stratigraphic
reference Name 1 position 2 Area (m <sup>2</sup> ) 3,4
I — — — Cueva de las Losetas — — — — — L/M — — — 43,500
(traps or snares)
IICueva al Lado del FaroL/M 61,500
(beside the lighthouse)
III Cueva del Lirio ———————————————————————————————————
(lily) IV———Cueva de los Pájaros ————————————————————————————————————
(birds)
V———Cueva de la Casa de Erickson————L-L/M————5,000
(Erickson's house)
VI———Cueva de la Playa Brava—————L/M—————13,000
(beach with heavy surf)
VII — Cueva de Doña Geña arriba— — — L-L/M — — — 2,500
(A former island resident.
Arriba connotes the upper of two adjacent caves)
VIII—Cueva Negra (black)—————— L———— 5,000
IX———Cueva del Diamante (diamond) ——— L/M 18,000
XCueva del Esqueleto $$ L/M $$ 20,500

Table 2. Other caves Stratigraphic Probable area A — Cueva del Norte (North) — — — — L/M — — — 1,000-5,000 B — Cueva de Frío (cold) — — — — — M — — — — 1,000-5,000 C -- Cueva del Basurero (garbageman) -- L/M -- -- 1,000-5,000 D — Cueva Caigo o no Caigo — — — — L/M — — — 1,000-5,000 ("I fall or I don't fall") E-- Cueva del Limón (lemon tree) --- L/M(?) -- 500-3,000 - Cueva del Mangle (mangrove) - - - L - - - - < 500 G -- Cueva del Portugués ----- L -- -- < 500 (the "Portuguese," a pirate)

H - - Cueva de la Cucaracha (cockroach) - - L - - - - < 500 - Cueva del Espinal (backbone) ---- L/M -- 1,000-5,000 - Cueva del Rifle (rifle) - - - - - M - - - 1,000-5,000<sup>6</sup>  $M -- Cueva del Toro (bull) ---- M(?) ----1,000-5,000^6$ N - - Sink-caves along Camino los Cerezos  $- L/M(?) - -5,000-170,000^7$ (Dogwood or cherry tree trail) 8 — Cueva la Hondonada (lowland) — — L/M(?)—— — <500  $^6$ 8-- Cueva el Cabro (goat) ----- L/M(?) -- 5,000-10,000 6 9 - - Cueva de la Escalera (ladder) - - - L/M

9 — Cueva del Caballo (horse) — — — — L/M 9 — Cueva del Subido (rise) — — — — L/M 10 — Cueva los Ingleses (Englishmen) — — L/M 10 -- Cueva del Rabo de Junco -- -- L/M (a variety of flowering vine)

11 — Cueva las Polaínas (spats) — — — L/M
12 — Cueva la Carmelita (proper name) — L/M

13 — Cueva de Mayagüez (city in western Puerto Rico) 13 — Cueva del Agua (water) 13 — Cueva de la Punta Alemana 13 - Cueva del Canadá (the nation) 13 — — Cueva del Este (east) 13 — Cueva de la Fé (faith)

13 — — Cueva del Nuevo Lirio (new lily) 13 — — Cueva del Ataúd (coffin) 13 — — Cueva de las Gallinas (hens) 13 — — Cueva de Café (coffee) 13 — — Cueva Escrita (written)

Totals 18,500-225,000

Cave names are those concurred with by P/O Victor González, Mona Island Light Station, U.S. Coast Guard (whose father was keeper of the Mona Island Light Station for many years) and Lieutenant Armando Henrnández and Officer Luis A. Ramírez, Police of Puerto Rico, except as noted. <sup>2</sup> M=cave floor in Isla de Mona Dolomite; L/M=cave floor at Isla de Mona Dolomite-Lirio <sup>3</sup> Areas of entire cave systems, including pillars and walls between passages and rooms. Areas of rooms and passages probably average about half of the total area of each system.

<sup>4</sup> Areas measured by polar planimetry of maps based on compass-and-tape and compass-and-pace traverses. Rounded to nearest 500 m. Believed accurate to within about 10 percent of true areas. Areas estimated by comparison with measured caves of apparently similar characteristics, <sup>6</sup> Area estimates from unpublished, undated report by Jorge González, San Juan. No general map accompanies this report. The written location descriptions are inadequate, but are sufficient to indicate that Mr. González may have used names for some of the caves that are

A number of small-diameter sinkholes along a part of Camino los Cerezos were observed to

not commonly applied. Mr. González could not be reached to date to clarify his report. The report probably was written between 1920 and 1940.

have passages leading laterally from their inaccessible bottoms. The higher of the area estimates assumes that these passages interconnect to form an integrated cave system of the size shown on the geologic map. However, it is most likely that the actual cave area in S Cave names used by Jorge González<sup>6</sup> and not otherwise located or identified. Cueva el Cabro, however may be a part of one of the west coast caves listed in table 1.

 $^{9}$  Cave names applied to parts of Cueva de los Pájaros (table 1, IV). 10 Cave names probably used for all or parts of Cueva de la Playa Brava (table 1, VI). 11 Cave name probably used for all or a part of Cueva del Esqueleto (table 1, X).

12 Cave name probably used for all or a part of Cueva del Capitán (table 1, XI). <sup>13</sup> Names of caves from which phosphorite was mined, but not otherwise identified (Wadsworth, 1954). Most of these names likely were applied to sections or large rooms in caves listed

ECONOMIC GEOLOGY Phosphorite.—Phosphorite, diagenetically altered bat guano,

is present in all the caves that we visited. The nature and extent of the phosphorite deposits are dealt with at length by Kaye and Altschuler (Kaye, 1959, p. 156-167). Original reserves of phosphorite probably were somewhat more than 150,000 m<sup>3</sup>, and mining between 1877 and 1924 removed most of these original reserves (Wadsworth, 1954). We estimate that fewer than 50,000 m3 of phosphorite remain, and this phosphorite is so distributed that it does not constitute an important or economic resource. Limestone.—The Lirio Limestone is essentially pure (Kaye,

1959, table 5), and is present in large quantities. The costs of transportation, however, make extraction of Lirio Limestone impractical. Dolomite.—The Isla de Mona Dolomite is largely calcitic dolomite with a very small content of noncarbonate minerals,

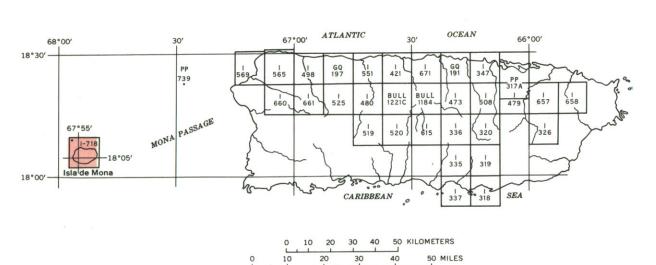
chiefly sulfates; the quantities of dolomite probably present are essentially limitless. Location of quarry sites would be difficult, for chief exposures of dolomite are in the sheer sea cliffs of northern Isla de Mona. Oil and gas possibilities.—No potential petroleum reservoir rocks are exposed in the Isla de Mona quadrangle, and no source rocks are known in the area. However, the structure of the islands and the widespread relatively impermeable blanket of Isla de Mona Dolomite suggest that oil or gas traps could

be present, provided suitable source rocks and permeable

layers are present at depth. No indications of oil or gas have

been confirmed from the vicinity of the Mona Passage. Water.—As of 1968, sufficient fresh water was gathered by roof catchment at Playa Sardinera and Mona Island Light Station to support the small and transient population, entirely government representatives on tours of duty, and occasional visitors. Shallow wells in the beach deposits and raised reef flat yielded brackish water or water of marginal quality. In addition, a small perennial pool of water occurs in Cueva de los Pájaros (table 1, cave IV), and a water seep was found in boulder deposits below Cueva del Capitán (table 1, cave XI). These latter features suggest that drilling in the upland surface may encounter fresh water in synclinal zones where the permeable Lirio Limestone rests on relatively impermeable Isla de Mona Dolomite, or in a lens near sea level, such as occurs in carbonate islands elsewhere in the world (J. P. Akers, written commun., 1964).

REFERENCES CITED Kaye, C. A., 1959, Geology of Isla Mona, Puerto Rico, and notes on age of Mona Passage: U.S. Geol. Survey Prof. Paper 317-C, p. 141-178. Wadsworth, F. H., 1954, Nuestra isla del tesoro (Isla de la Mona): Depto. Instrucción Pública, ser. 3, no. 24, 59 p.



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